HFR-Free Material Dk/Df Test Method Proposal

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30 Apr 2009

OUTLINE

I. Driver for Cisco Interest

II. HFR-Free Materials – Dk/Dk Testing

III. Towards a New Dk/Df Test Method

I. Driver for

Cisco Interest

From Cisco's 2008 Materials Roadmap:

Top-Level Goal for Pb-Free Linecards

Direct replacement of

HIGH-LOSS PHENOLICS

with reduced / lower-loss

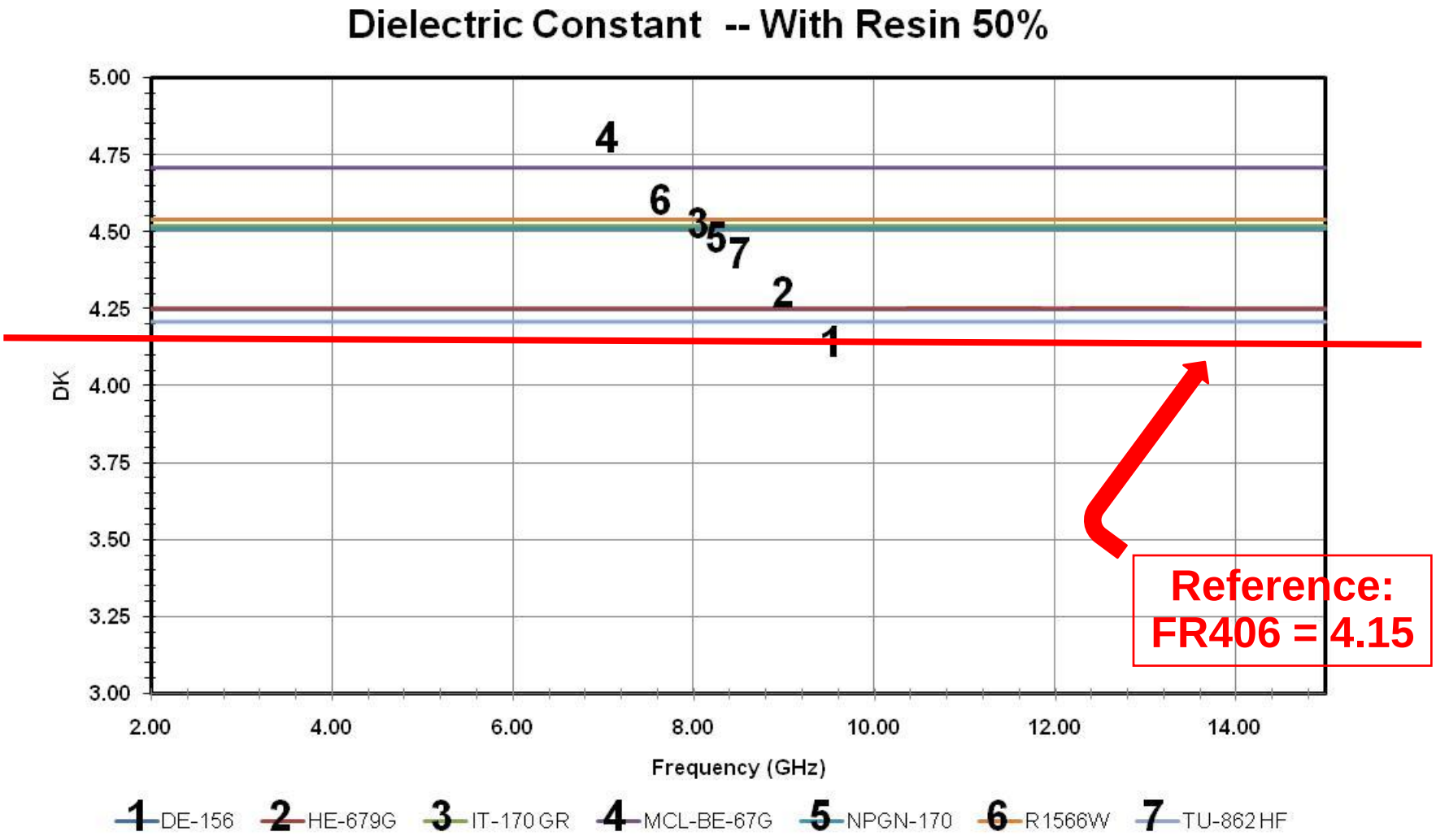
HALOGEN-FREE MAT'LS

(…at minimal cost impact…of course!)

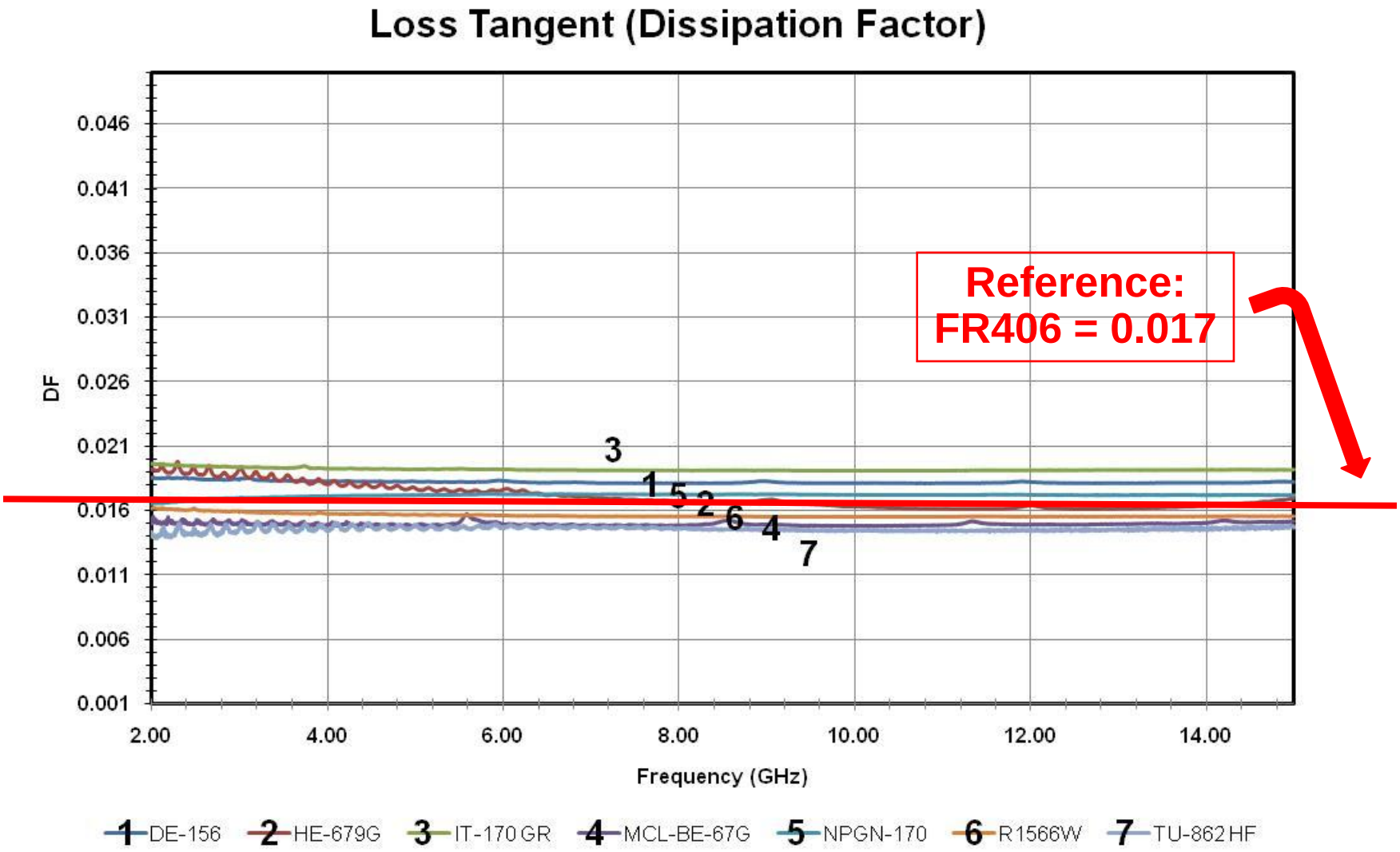
II. Dk/Df Testing

Halogen-Free Materials

HFR-free material Dk test results



HFR-free material Df test results



HFR-free: New materials planned

FY'10 Test Plan

- **Hitachi BE-67G(R) or G(S)**
- **EMC EM-285 or 280(H)**
- **Ventec VT-447**
- **(?) Panasonic R-1577***

** Release date-dependent*

III. Towards a New

Dk/Df Test Method

Top-Level Goal

Gain acceptance of our Dk/Df test method as an official IPC Industry Standard in TM-650

START: SUMMER 2009

WHY…?

… No industry consensus on methods
… Existing methods: single data points
… Apples/oranges between datasheets

General challenges around Dk/Df

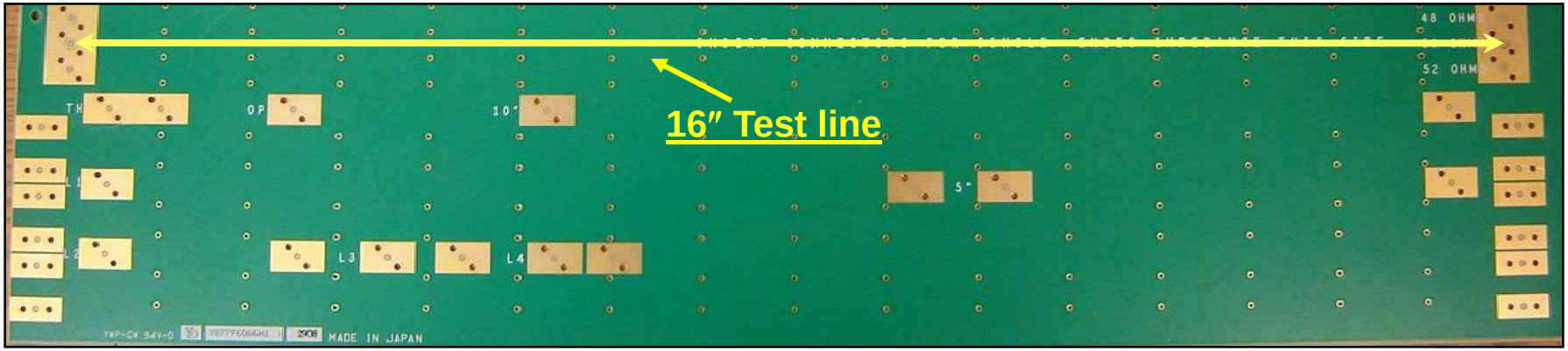
- No NIST-traceable “gold standard” for Dk/Df
  - RESULT: No way to know that a given Dk/Df measurement is “correct”
  - RESULT: No way to know that a modeled Dk/Df is “correct”
- No industry consensus on test methods
  - IPC: Official in TM-650: 2.5.5.x (total 10 methods)
  - JIS: Tri-plate resonator
  - RESULT: Datasheet Dk/Df values don’t correlate across laminate mfr’s
- Cisco/MST: Converge better test method & algorithm
  - Test method: No tuned resonators, real-life PCB, many sample points
  - Algorithm: Physics-based; address simplifications in existing models
  - Desired Endpoint 1: Measured Dk/Df curves overlay modeled curves
  - Desired Endpoint 2: Library of apples-apples curves for WW laminates

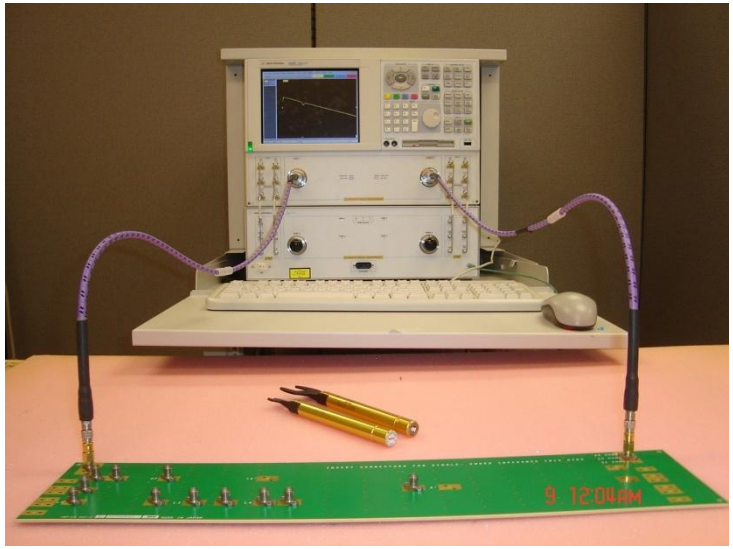
Current IPC Methods vs. Cisco/MST

- X-band, Stripline “Sandwich”, Split-Cylinder, Bereskin, FSR
  - All employ tuned resonators -- TV’s do not resemble real PCBs
  - Require TV structures tuned to specific frequencies
  - Result yielded: Dk/Df at individual freq. points (Loss → Df , Phase → Dk)
  - Interpolation required between measured points
  - Dk/Df extraction algorithms are fairly simplistic (Hammerstad, 1975)
  - Algorithms based on ideal (perfectly smooth Cu) traces
- Cisco / MST test method: For 2+ GHz
  - “Real PCB” stripline TV – Not a tuned resonator
  - Calibration structures built into the board itself (TRL calibration)
  - Thousands of discrete measurements (at ~5 MHz intervals)
  - Result yielded: (Effectively) continuous Dk/Df curves; no interpolation
  - Dk/Df extraction algorithms updated to account for Cu roughness

Structure of test vehicle

Top view of Cisco / MST Stripline Test Vehicle

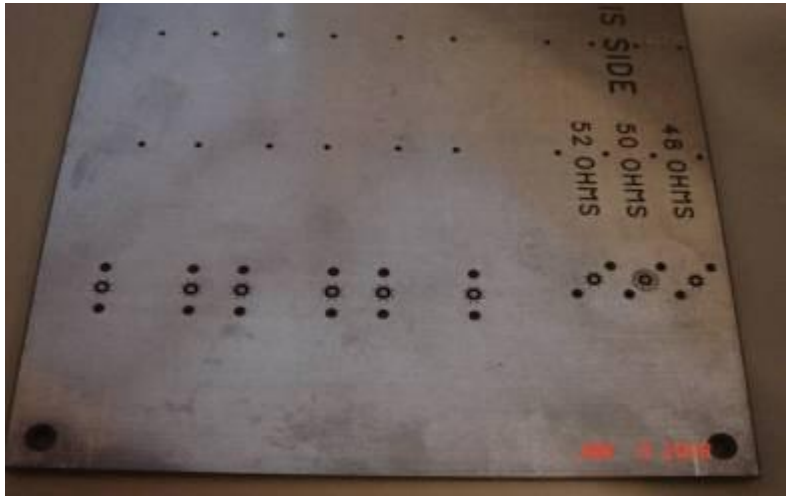




Agilent E8364B PNA-series Vector Network Analyzer

Stripline TV Structure

The Stripline TV includes both 50Ω SE and 100Ω diff pairs and accepts SMA connectors.



The Molex SMA connectors are of the compression-mount style. (Molex P/N 73251-1850)

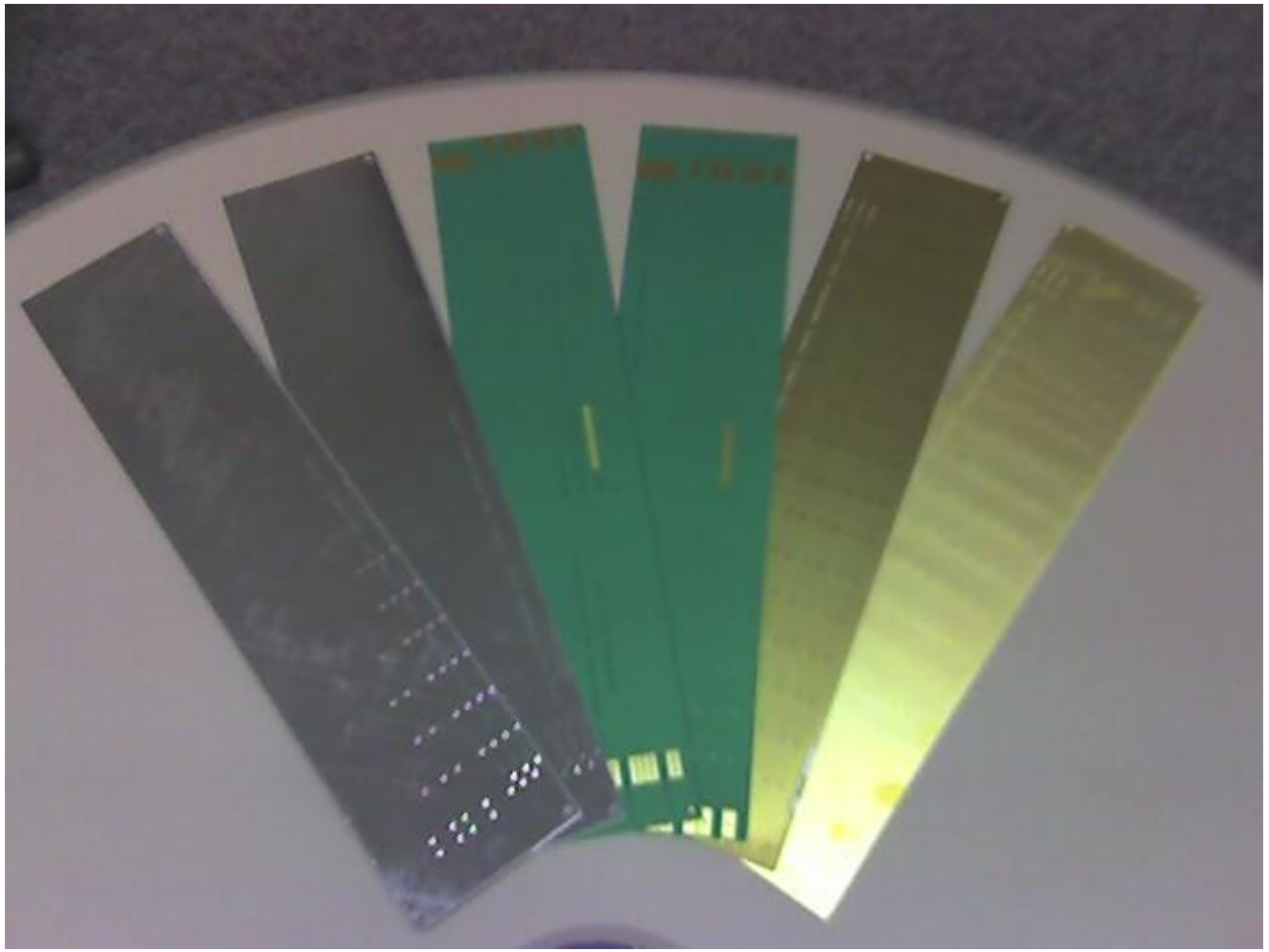
Trace length 16” (406mm)

Stripline TV Stackup

-- Six-layer PCB, 17.5” x 4” x .093”
-- Two 3-layer, balanced stripline structures
    - ~0.010 dielectric on both sides
    - Target 50% RC (usually 2x2116)
-- Layer 2 is 50Ω SE and Layer 5 is 100Ω Diff pairs
-- Layers 1, 3, 4, 6 are GND reference
-- Dummy material between Layers 3 and 4
-- Three adjacent SE/Diff pairs, to allow best match
    - SE = 48, 50, 52 ohms
    - Diff = 96, 100, 104 ohms
-- SMA mounted on far side → via stubs .012” nominal
    - No backdrilling (for this iteration)
    - Stub length variation from BD is undesirable

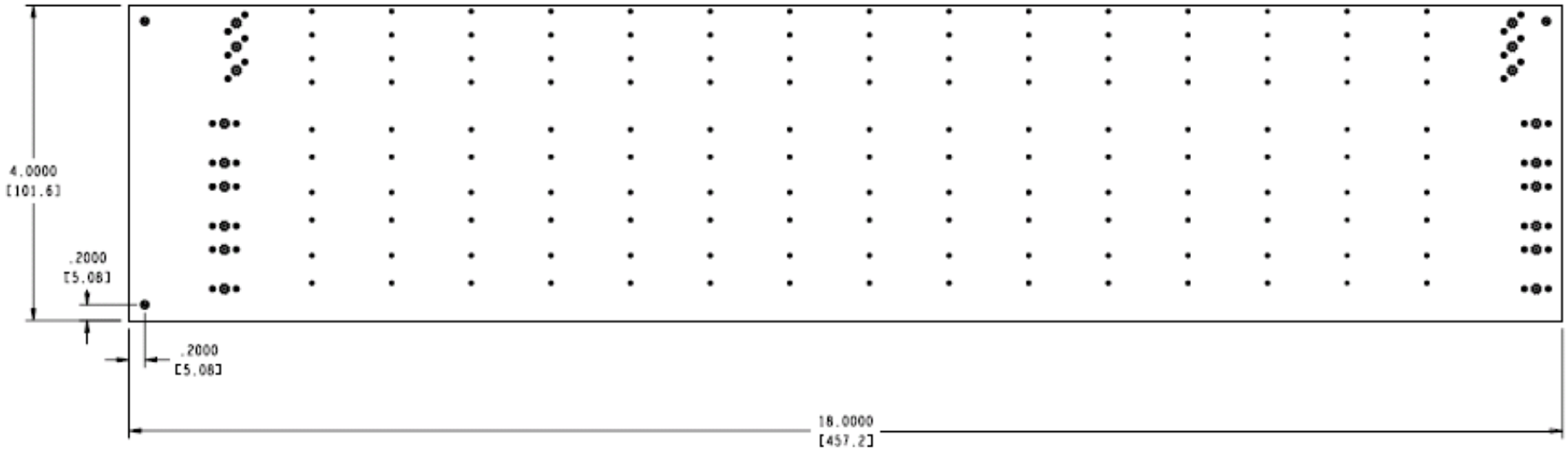
Test Program Details

EXISTING TV SET: ~ 40 MATERIALS



Test Program Details

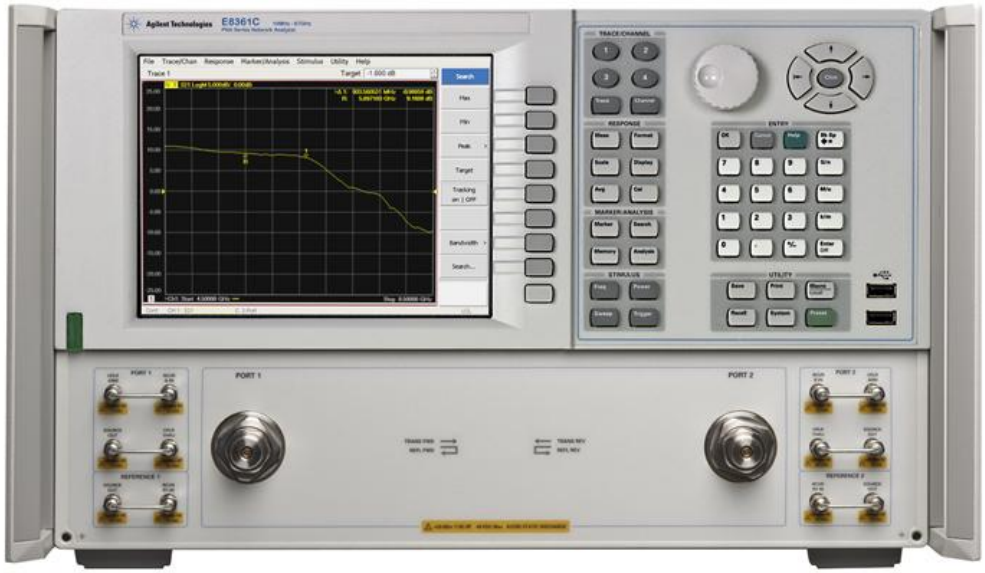
GERBER DATA FOR TV AVAILABLE



… for those who want to replicate, or add new materials to the S-parameter and Dk/Df database!

Test Program Details

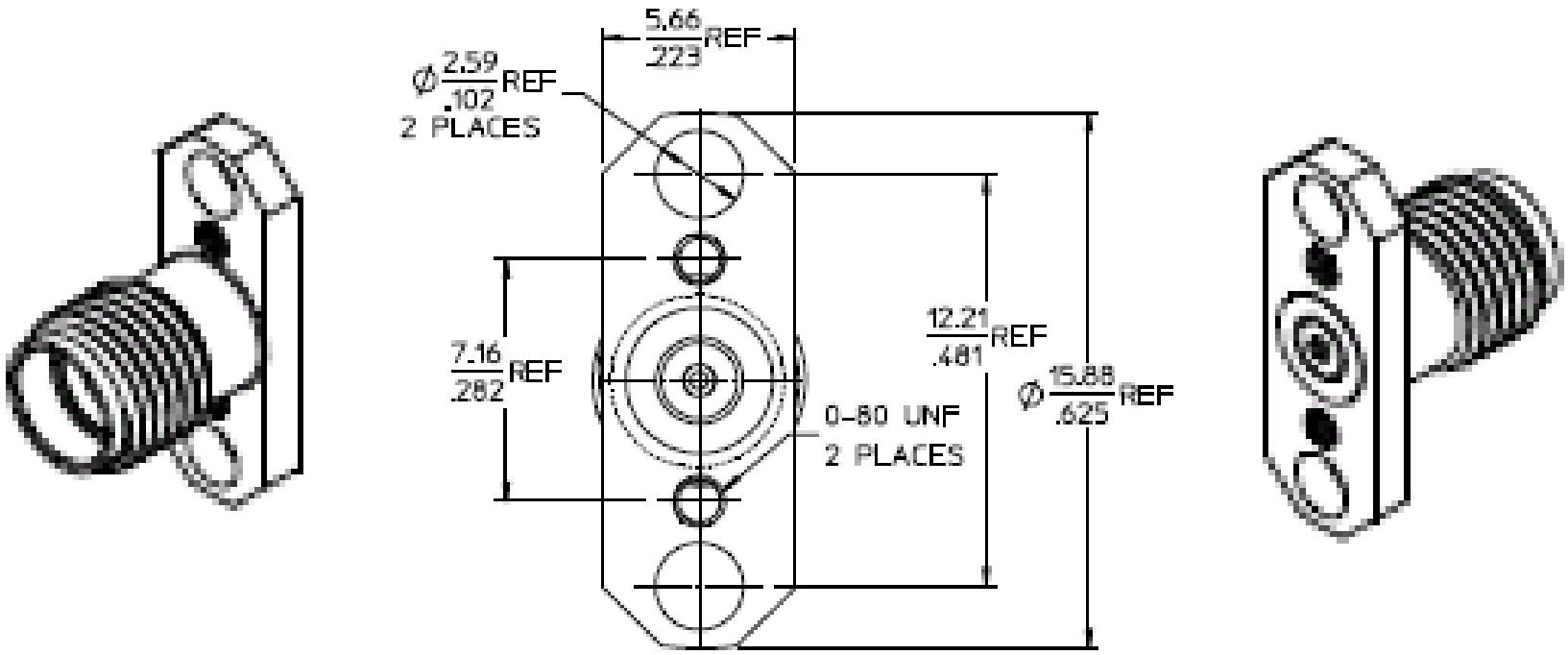
VNA CAPABILITY MUST BE VALIDATED



30GHz, 2- OR 4-PORT VNA WITH LOW-LOSS CABLES…

Test Program Details

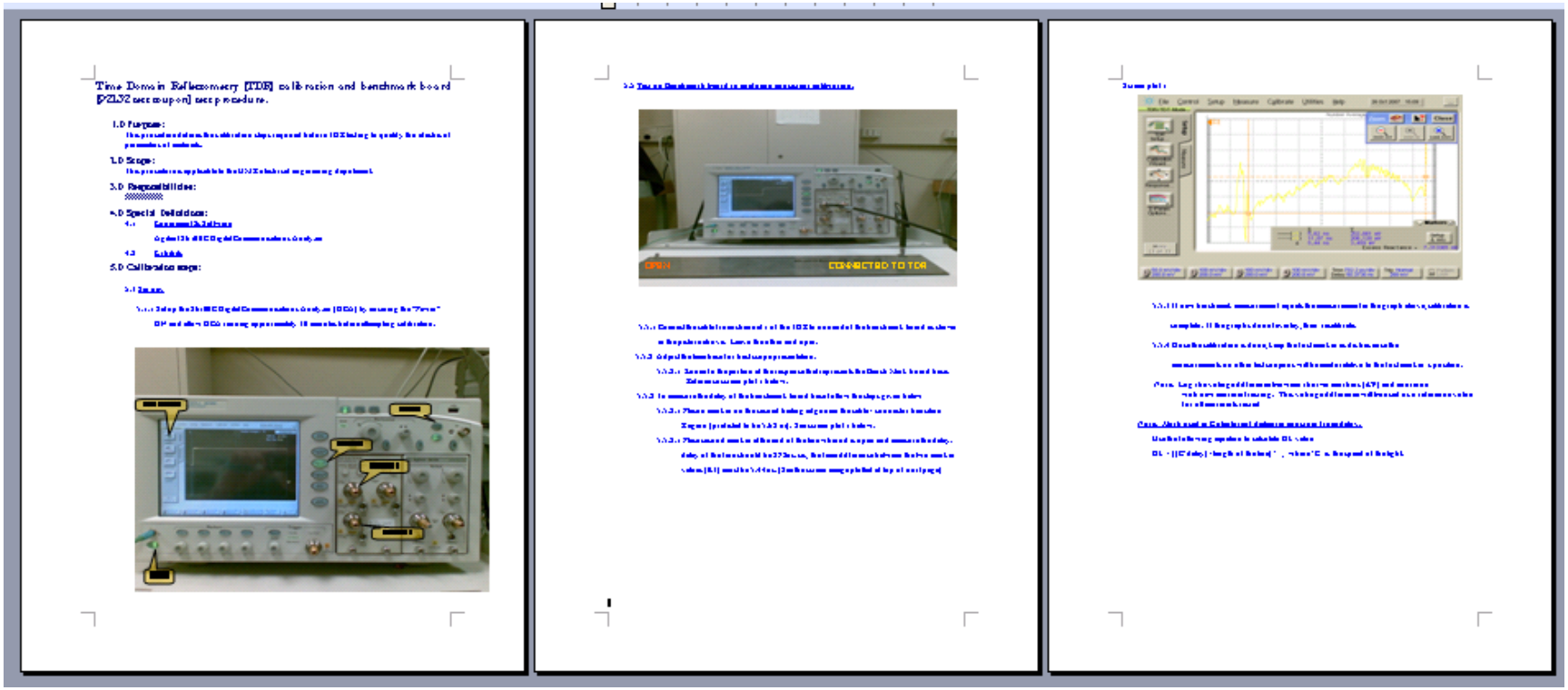
STANDARDIZED CABLES & SMA…



FLANGE-MOUNT SMA TYPE
MOLEX P/N 73251-1850

Test Program Details

STANDARDIZED VNA CALIBRATION PROCEDURE…



Test Program Details

S2P (OUTPUT) FILES OF OUR ACTUAL S-PARAMS AVAILABLE AS REFERENCE

```
!Agilent Technologies,E8364B,MY43040876,A.07.50.23
!Agilent E8364B: A.07.50.23
!Date: Saturday, February 23, 2008 18:57:00
!Correction: S11(Full 2 Port(1,2))
!S21(Full 2 Port(1,2))
!S12(Full 2 Port(1,2))
!S22(Full 2 Port(1,2))
!S2P File: Measurements: S11, S21, S12, S22:
# Hz S  dB   R 50
10000000 -2.378200e+001 5.673628e+001 -2.584631e-001 -1.376380e+001 -3.022304e-001 -1.376806e+001 -2.340713e+001
6.027135e+001
19368750 -2.642289e+001 3.853881e+001 -2.925846e-001 -2.174982e+001 -3.004267e-001 -2.168536e+001 -2.623681e+001
3.703846e+001
28737500 -2.745473e+001 1.856262e+001 -3.267293e-001 -3.080593e+001 -3.389186e-001 -3.078322e+001 -2.754905e+001
1.993869e+001
38106250 -2.797746e+001 2.983054e+000 -3.553250e-001 -3.985679e+001 -3.524945e-001 -3.985023e+001 -2.856044e+001
6.122039e+000
47475000 -2.863589e+001 -1.382138e+001 -3.932017e-001 -4.905007e+001 -3.875628e-001 -4.905552e+001 -2.902165e+001 -
8.903451e+000
56843750 -2.882035e+001 -2.572735e+001 -3.992082e-001 -5.837532e+001 -4.042186e-001 -5.839590e+001 -2.906086e+001 -
1.948173e+001
66212500 -2.871365e+001 -3.886808e+001 -4.229536e-001 -6.772903e+001 -4.405320e-001 -6.768130e+001 -2.969986e+001 -
3.316959e+001
75581250 -2.900070e+001 -5.031157e+001 -4.598562e-001 -7.701940e+001 -4.710527e-001 -7.688477e+001 -3.072489e+001 -
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84950000 -2.910805e+001 -6.559148e+001 -4.807650e-001 -8.627347e+001 -5.028333e-001 -8.628214e+001 -3.121009e+001 -
5.532522e+001
94318750 -2.973300e+001 -7.703996e+001 -5.914595e-001 -9.588406e+001 -5.671583e-001 -9.575095e+001 -3.244051e+001 -
6.958324e+001
103687500 -3.051751e+001 -9.205621e+001 -6.107419e-001 -1.050999e+002 -5.929309e-001 -1.050908e+002 -3.372701e+001 -
```
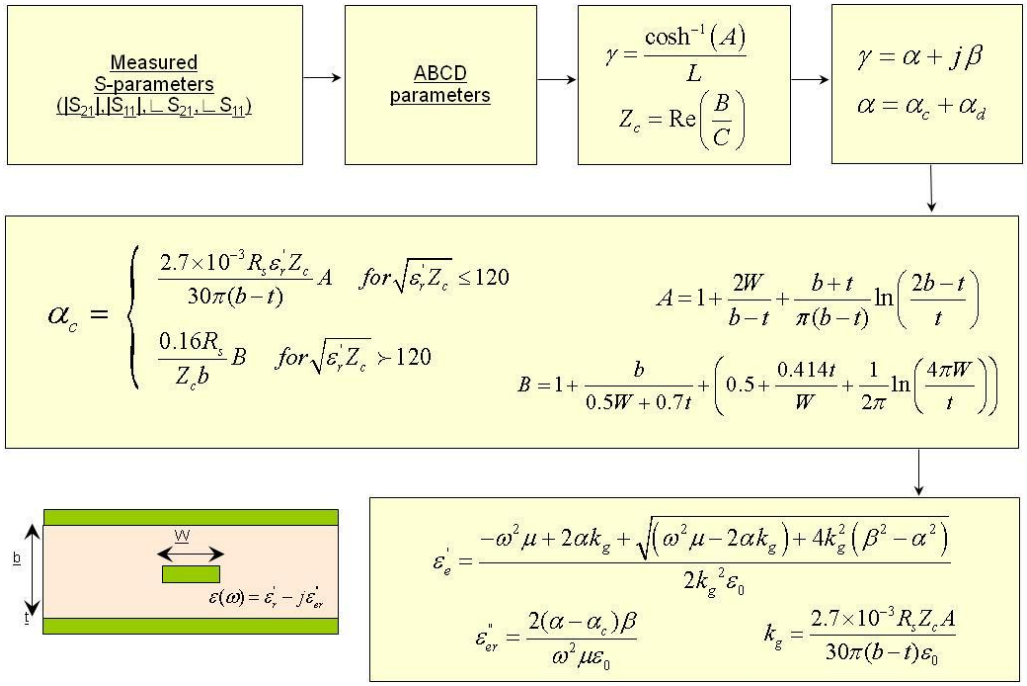

Test Program Details

DRIVE S-PARAMS THRU CISCO/MST Dk/Df EXTRACTION ALGORITHM…



…TO GET Dk/Df SWEEP CURVES

How we'll get there…

1. **Identify suppliers with VNA capability**
2. **Distribute test procedure and algorithm**
3. **Validate capability at sites (4-5 preferred)**
4. **Select materials with wide range of Dk / Df**
5. **Round-robin testing at participating sites**
6. **Find causes of variation; debug procedure**
7. **Calculate R&R, and if acceptable…**
8. ***Submit to IPC D-24 test methods committee***

Q and A